REMARKS

The Examiner's objection to the form of Claim 11, which did not start on a separate line, has been addressed and corrected.

Claims 7-18 were rejected under 35 U.S.C. §102(b) as being anticipated by US Pat. 5,976,088 (Urbano et al.) Amended Claim 7 describes a method of generating an ultrasound image, comprising repetitively transmitting ultrasound into a region of interest; receiving ultrasound echo signals resulting from each of the transmissions; sampling the ultrasound echo signals to provide echo signal samples; creating a plurality of ultrasound image frames using a preliminary value for a frame rate at which the ultrasound image frames will be created and a preliminary value for the number of transmissions over which the echo signal samples are to be averaged to create the ultrasound image frames; analyzing the ultrasound image frames or the manner in which the ultrasound image frames were created using the preliminary values, wherein analyzing comprises analyzing the ultrasound image frames that were created using the preliminary values to determine the frame-to-frame changes corresponding to movement of imaged physiological structures; based on the analysis, determining a final value for the frame rate and a final value for the number of transmissions over which the echo signal samples are to be averaged to create the ultrasound image frames; creating ultrasound image frames using the final value for the frame rate and the final value for the number of transmissions over which the echo signal samples are to be averaged to create the ultrasound image frames; and displaying an ultrasound image using the created ultrasound image frames. An implementation of the invention of Claim 7 eliminates noise in an image which is particularly inherent at greater imaging depths by averaging a number of temporally different echo signal samples, with the number of samples being averaged at

any particular moment being a function of the movement of physiological structures in the image to prevent blurring in the images. For instance, when the user is imaging the liver, where little motion is present, a greater number of samples will be averaged to achieve significant noise reduction. But when the user moves the probe to image the heart, which is always in motion, the number of samples being averaged will adaptively drop to a lower number to preserve clarity of the imaged moving heart. In some cases the heart motion may be so rapid (*e.g.*, a heart valve) that the number of samples being averaged drops to one, meaning that there is no averaging and the images preserve the greatest temporal resolution possible.

Urbano et al. are doing something different. They are trying to acquire images efficiently by only acquiring a new image when changes causes by motion dictate that a new image is needed. If there is no motion, Urbano et al. recognize that a new image will be the same as the previous one, and the new image "would be redundant." Thus, they do not acquire one. As they say in col. 11, lines 7-10, "there is a time period in which a full resolution sample could be taken based on the capabilities of the equipment, but is not taken, since the image data would be redundant." During this "dead time" between their "full resolution" images they acquire "low resolution interrogation frames" with a lower line density than a full resolution image. Each new low resolution frame is compared with the last full resolution image and, when a noticeable difference is found between the two, they realize that a new image would not be redundant due to a change in the image and a new full resolution frame is acquired. The example application they cite for their system is heart imaging, where the heart is moving more rapidly during systole than it is during the diastolic phase of the heart cycle. See col. 17, lines 37-41. Their system would then acquire frames at a higher frame rate during systole than diastole, meaning

that their cardiac cycle loop would not have any redundant frames but would have a constantly changing frame rate.

In Urbano et al. each displayed image is only a single frame with no adaptive averaging of samples from multiple acquisitions as is the case with the present invention. Urbano et al. address noise problems only in their frame-to-frame correlation, where they use thresholding to eliminate low level pixels. See col. 13, lines 59-61. They do mention an optional temporal filter at col. 15, lines 26-34, but this filter is described as a non-adaptive temporal filter which combines either a fixed number of frames or a fixed recursive time constant. Urbano et al. state specifically here that "The total number and time periods of the collection image frames would be the same as in a scheme without temporal filtering." Thus, they purposely avoid making use of the "dead time" between their full resolution images to acquire more full resolution images for temporal averaging. Their purpose is to acquire only the minimal number of high resolution frames needed to depict extant motion, not to acquire extra high resolution frames that could be used to improve noise effects by temporal averaging. It is seen that Urbano et al. actually teach away from the present invention since their purpose is acquisition efficiency, not greatest noise improvement.

In the latter part of their patent from col. 18 to the end Urbano et al. propose cycle-to-cycle filtering. That is, they would acquire images from multiple heart cycle and combine the first frames of each heart cycle, and the second ones, and the third ones, and so forth. They admit at col. 27, lines 55-56 that this is based on the assumption that "the physiologic cycles are assumed to be periodic and very similar from cycle to cycle," a very questionable assumption. While this is at times the case for normal people, patients undergoing cardiac ultrasound exams are frequently doing so because they exhibit an arrhythmia which causes their heart

cycles to vary from one to another. The heart cycle will also vary normally with exercise and even with emotions such as stress. So the respective frames from different cycles are likely to be different. At 30 frames per cycle, this filtering over multiple heart cycles would require massive frame storage and processing. On top of all that, Urbano et al. want to use a continually varying frame rate over each heart cycle to achieve their efficiency objective, making cycle-to-cycle frame correspondence even more unlikely. In any event, ultrasound images are not created based on an adaptive determination of frame rate and number of echo samples to be averaged as recited in Claim 7.

For all of these reasons, it is respectfully submitted that Claim 7 and its dependent claims are not anticipated by Urbano et al. which, when carefully examined, are seen to be doing something entirely different for an entirely different objective. In addition, the dependent claims add further factors to the claimed analysis such as the depth of physiological structures and the image sector width which are also not considered by Urbano et al.

Amended Claim 11 describes an ultrasound diagnostic imaging system comprising an ultrasound scanhead including an array transducer; an ultrasound transmitter coupled to the array transducer in the scanhead to apply transmit signals to the array transducer; a controller coupled to the transmitter, the controller being operable to trigger the ultrasound transmitter to repetitively apply transmit signals to the array transducer thereby causing the array transducer in the scan head to transmit ultrasound into a region of interest, the controller further receiving a minimum value of a first operating parameter from a user control, the first operating parameter being a minimum acceptable frame rate FR_{MIN} at which the image frames are to be created, the controller further determining a value for a second operating parameter that is different from the first operating parameter based on the

minimum value FR_{MIN} of the first operating parameter, the second operating parameter being the number of transmissions over which the echo signal samples are to be averaged to create the ultrasound image frames or the frame rate at which the image frames are to be created; a beamformer coupled to the controller and to the array transducer in the scanhead to receiving ultrasound echo signals resulting from each of the transmissions and form the received ultrasound echo signals into beams; a processor coupled to the beamformer, the processor being operable to create ultrasound image frames using the minimum value FR_{MIN} of the first operating parameter and the determined value of the second operating parameter; and a display coupled to the processor, the processor being operable to display an ultrasound image using the created ultrasound image frames. An embodiment of Claim 11 allows the ultrasound system user to select the minimum frame rate he or she will find acceptable. The system then determines whether this minimum can be achieved or enhanced imaging can be done such as sample averaging to reduce noise. For example, the user may select 10 frames per second as being minimally acceptable, but the system may determine that a frame rate of 15 frames can be achieved even with some sample averaging. The system would thus provide a higher frame rate than the minimally acceptable one, and with sample averaging to reduce noise in the image.

The Urbano et al. system is completely automatic, with no provision for user input of a minimally acceptable frame rate. In fact, the Urbano et al. system does not strive for the highest possible frame rate, it strives for the most efficient by not acquiring frames that would be "redundant." And, as mentioned above, there is no adaptive sample averaging in the system of Urbano et al. For all of these reasons it is respectfully submitted that Urbano et al. cannot anticipate amended Claim 11 and its dependent claims. Some of the dependent claims introduce further features not present in

Urbano et al., such as considering the type of ultrasound examination being conducted and the estimated depth of physiological structures in the region of interest. These independent claims are not anticipated for this further reason.

Claims 7-18 were also rejected under 35 U.S.C. §102(e) as being anticipated by US Pat. 6,544,177 (Robinson) which was cited by applicants. Robinson is doing harmonic spatial compounding and spatial compounding involves the combining of component frames acquired from different look directions. Since frames acquired from different directions cover different areas, the compounding effect is greatest where the greatest number of frames overlap, referred to as the RMIQ in Figs. 9A, 9B and 9C of Robinson, and less in other areas of lesser overlap. For this reason the number of frames to be combined in any given area is purely a function of the image geometry. Once the image geometry has been determined, the system simply looks up the number of frames that can be compounded as illustrated in Table 1 of Robinson. No consideration is given in Robinson to frame-to-frame changes corresponding to movement of imaged physiological structures as recited in amended Claim 7. There is also no provision in Robinson of user input of a minimum acceptable frame rate with the system possibly determining a better frame rate from the minimum acceptable value and a second parameter of sample averaging for noise improvement or a higher frame rate of display, as recited in amended Claim 11. In Robinson, the image geometry determines the system performance. The dependent claims add further features not found in Robinson. For these reasons it is respectfully submitted that Robinson cannot anticipate Claim 7 or Claim 11 or their dependent claims.

In view of the foregoing amendments and remarks, it is respectfully submitted that Claims 7-18 as amended cannot be anticipated by Urbano et al. or Robinson. Accordingly it is

respectfully requested that the rejection of Claims 7-18 under 35 U.S.C. §102 be withdrawn.

In light of the foregoing, it is respectfully submitted that this application is now in condition for allowance. Favorable reconsideration is respectfully requested.

Respectfully submitted,

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